VARIATION OF DIATHERMANCY WITH THE TEMPERATURE OF THE RADIATING SOURCE.

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ABSTRACT.

Instrument for measuring radiant heat energy.—The radiation is focused by a mirror on a thin piece of copper oxide, 1 mm.² in area, with a resistance of 10,000 ohms and a temperature coefficient of resistance of 0.01 per degree. Such an instrument is simple to construct and use and is easily made sensitive to one per cent. of the radiation from a tubular electric furnace at 500° C.

Diathermancy of various substances to the total radiation from a tubular furnace for temperatures from 200 to 1,200° C.—For furnace temperatures of 400, 700 and 1,000° the percentages transmitted are as follows: *water* (½ mm.), 4.6, 14.4, 24.8; *ice* (3 mm.), —, 4.6, 15; *rock salt* (11 mm. clear), 85.6, 87, 89; *white mica* (1 mm.), 6, 14, 29; *glass* (1.2 mm.), 10.6, 22, 40. A column of *moist air* 2.5 meters long containing 0.032 mm. of precipitable water absorbed 8.7 and 7.1 per cent. for temperatures of 510 and 850° respectively.

As early as 1833, the experiments of De la Roche and Melloni showed that many substances are very transparent to visible radiation but decidedly athermanous to the longer heat waves. Glass for example transmits very little of the radiation until the source of the radiation is red or white hot; that is, the visible part of the spectrum must be comparatively intense before much radiant energy is transmitted through glass. A few substances like rock-salt are both transparent to the visible portion and diathermanous to the infra-visible portion of the spectrum. A great amount of experimental work on diathermancy with particular attention to pure gases and moist air was done by Tyndall,[1] Magnus[2] and others in the latter half of the nineteenth century and these early experiments indicated that the amount of radiant energy transmitted through the various substances depended on the character of the radiation.

It is the purpose of this paper to describe the results of experiments to determine the per cent. of the total radiation that is transmitted through several substances and to show the variation of the transmission with the temperature of the radiating source. All substances show selective absorption to some extent; and therefore the per cent. of the incident radiation that is transmitted depends on the character of the radiation. The radiation from a furnace becomes richer and richer in the shorter waves as the temperature of the furnace is increased; therefore

[1] "Contribution to Molecular Physics," p. 172.

[2] Phil. Mag., Vol. XXII., 1861.

increased temperature will improve the transmission through substances that are very transparent but not very diathermanous.

The general plan of the experiments was to focus the radiation from a tubular electric furnace on a sensitive electrical resistance element and interpose the substance to be examined between the furnace and the concave mirror which focused the radiation on the resistance element. The concave mirror with polished metal surface does not appreciably change the character of the radiation. The intensity was measured by the change in the electrical resistance of the element at the focus of the mirror, produced by the heating effect. This element is a thin piece of copper oxide about one square millimeter in cross-section, with two connecting wires making electrical connections to the edges of the oxide at

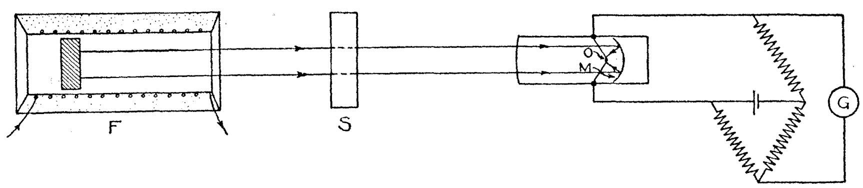

Fig. 1.

opposite sides. The resistance of the element is about 10,000 ohms at room temperature with a negative temperature coefficient of resistance of about .01 per degree. With this oxide resistance forming one arm of a wheatstone bridge, a radiation measuring instrument is thus obtained which is easily sensitive to one per cent. of the radiation from a furnace at 500° C. or one tenth of one per cent. of the radiation from a furnace at 1200° C.

Figure 1 shows the arrangement of the apparatus; S is a plate of the material being examined, F is a tubular electric furnace, and M is the concave mirror focusing the rays from the furnace on the oxide resistance element O. The plate S was replaced by a stream from a nozzle when water and steam were examined, and the brass tube with rock-salt windows was placed between the furnace and the mirror when the absorption of moist air was measured. The temperature of the furnace was measured with a calibrated platinum-iridioplatinum thermo-couple.

The results show a decided increase of diathermancy with temperature for all substances examined except for clear rock-salt; and even it shows some increase. Glass may transmit not more than 6 per cent. of the total radiation when the furnace temperature is 200° C., 15 per cent. when temperature is raised to 500° C., and 60 per cent. when the furnace temperature reaches 1200° C. White mica transmits only about one per cent. when the radiating source is at 200° C., but its transmission increases to 40 per cent. when the temperature of the source is raised to 1200° C. Ice and water are decidedly athermanous to the total radiation from a furnace at 400° or 500° C., but may transmit 20 or 25 per cent. when the temperature of the furnace is raised to 1000° C. A thin jet of steam about 1.5 mm. thick does not absorb as much as one per cent. for temperatures ranging from 500° C. to 1000° C. if care is taken not to allow condensation at the surface of the steam in contact with the cooler air. This condensation was prevented by keeping the air in contact with the steam at a higher temperature than the steam. However, a column of moist air 2.5 meters long absorbs about 9 per cent. of the radiation from a furnace at 500° C. The water vapor in the column of moist air which was 70 per cent. saturated at 70° F. was equal to .032 mm. of precipitable water; the thin steam jet, to only .0009 mm.

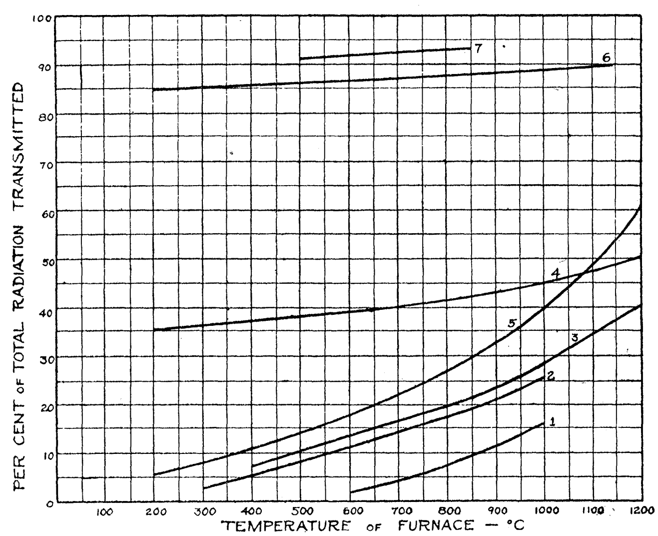

Fig 2.

(1) 6 mm. of ice.
(2) 0.5 mm. of water.
(3) 1 mm. of mica.
(4) 11 mm. of rock salt (dull).
(5) 1.2 mm. of glass.
(6) 11 mm. of rock salt (clear).
(7) 2.5 meters of moist air (70° C., 70 per cent. humidity)

The plan of intercepting the rays with water or steam was to allow a thin stream to flow from a flat nozzle in front of the focusing mirror. Moist air was examined by measuring the increased transmission through a brass tube 2.5 meters long with rock-salt windows at each end when the air was pumped out of the tube. The tube was evacuated to a pressure of about 5 millimeters.

Temperature of Furnace, ° C.	Per Cent. Transmitted.
Water (.5 mm.).	
300	2.9
370	4.0
4 5	5.3
540	9.0
560	9.9
580	10.3
625	11.4
670	13.3
680	13.6
685	13.8
720	15.2
730	15.3
760	15.7
810	18.1
820	18.7
870	20.6
930	22.8
940	23.0
960	23.6
Ice (3 mm.).	
660	3.4
720	5.2
790	7.6
865	9.9
910	11.7
925	11.9
960	14.2
Mica (1 mm.).	
350	5
410	7
565	12
770	18
895	23
1050	31
1170	39

Temperature of Furnace, ° C.	Per Cent. Transmitted.
Moist Air (.032 mm. Precipitable Water).	
510	91.3
590	92.2
735	92.6
780	92.6
760	92.6
820	92.7
850	92.9
Rock Salt, Clear (11 mm.).	
200	85.0
300	85.5
400	85.6
500	86.0
600	86.4
700	87.0
800	87.4
900	87.7
1000	89.0
1100	89.5
Glass (1.2 mm.).	
200	5.8
290	8.0
360	9.6
475	12.5
540	15.6
660	20.2
700	22.0
810	27.2
890	31.0
975	37.5
1100	49.0
1185	59.0

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